

# Health & Safety *Report*

Worker Health and Safety Branch

HS-1850

Monitoring of Ground Applicators Applying Pesticides in  
Arbor Trellised Vineyards or T-type Cross Arm Trellised Vineyards

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## Introduction

This study was conducted to estimate the exposure of workers applying pesticides in arbor trellised and T-type cross-armed trellised grape operations in California. The T-type trellis is a bilateral cordon trained system having cross arms with catch wires running the length of the row, as shown in figure 1. In arbor trellised operations, the vines and grapes grow along the vertical posts and horizontal supports, trained upward along a support system of wood, metal and wire to form an enclosed canopy over the row. Growers use a variety of configurations, including flat and gabled canopy trellises as shown in Figure 2 and 3. Initial conversion and on-going maintenance costs are significantly higher for this type of trellised operation. Advantages can be increased yields, fewer herbicides are necessary since the canopy shades weeds out, and harvester exposure is likely reduced, because the grapes hang within easy reach. The harvest workers do not have to immerse themselves in the foliage, so there is less contact with potentially treated leaves. Additionally, the canopy provides a more comfortable, shaded environment in which to harvest.

Vineyard pesticide applications can be made using sprayers treating one side of two rows in a single pass or an over-the-vine sprayer treating both sides of two rows in a single pass. Whether tractor drawn or mounted to the tractor, applicators can use enclosed cabs in the T-type trellis system. Since the arbors average just 6 - 7 feet in height at the row ends, the use of enclosed cab equipment is not possible. Applications place the applicator on the tractor without the possible benefit of a cab and the sprayer pulled behind directs the spray upwards but contained within the enclosed canopy. In this scenario, it was thought the pesticide might have a greater potential of contacting the applicator.

The Department of Pesticide Regulation (DPR) Enforcement staff observed applications made in trellised vineyards and



Figure 1. T-type cross-arm trellised vineyard shown with an over-the-vine sprayer.



Figure 2. Flat canopy type trellised vineyard.



Figure 3. Gabled canopy type trellised vineyard. Note cross members.

identified potential concerns about worker exposure. Enforcement staff requested the Worker Health and Safety Branch (WH&S) to evaluate whether exposures could be greater for applicators when spraying vineyards using the arbor trellis support system. WH&S conducted a study to estimate pesticide exposure to applicators spraying both the arbor trellis vines and the T-type trellised vines. Measurements included sampling of the workers' breathing zone and dermal exposure monitoring via clothing (shirts, socks), and patch dosimeters, hand wipes, and face/neck wipes. This investigation was designed to evaluate the relative exposure potential of applications in arbor versus T-type trellised vineyards by monitoring experienced workers under actual use conditions.

## Methods

The intent of the study was to monitor applicators working in vineyard operations that have both the arbor trellis support system and the T-type trellising system of vertical posts and horizontal supports. Exposure monitoring could then be conducted in both trellising systems on every monitoring day and for the same pesticides. This was not always feasible, as pest pressures sometimes required different pesticide treatments. Additionally, upon discussion with the cooperators, it was anticipated to monitor workers applying methomyl to the vineyards more than once in a season but in the initial year of the study pest pressures and practices changed and only one treatment of methomyl was needed. The study was conducted an additional year but no methomyl use was occurring and the decision was made to monitor applications of the pesticides iprodione, imidacloprid and myclobutanil for worker exposure.

The protocol detailing the study subject consent process was approved by the University of California, San Francisco, Committee on Human Research, approval number H7420-11728-02. Workers participating in the study provided their signed informed consent. Workers conducted their usual work activities wearing personal protective equipment required by the pesticide label.

### Study Dates

Protocol approved	April 30, 1995
Ethical protocol approved	June 8, 1995 (Approval was renewed the next two years and expired June 1, 1998)
Field monitoring started	June 11, 1996
Laboratory sample analysis started	June 17, 1996
Field monitoring completed	May 30, 1997
Lab sample analysis completed	October 8, 1998
Study completed	Date of front cover sheet

All monitoring of applicators took place in the southern San Joaquin Valley where the arbor trellis system is used in the production of table grapes. Table 1 shows the monitoring dates, acres monitored and the pesticides sprayed. By observation shoot growth from the mature vines was estimated to cover at least 80% of the flat and gable trellised vineyards at the time of monitoring. Spraying usually began in the evening at approximately 1900 hours and would continue until completing the night's treatments. Applicators drove their tractors to the mixing and loading site or a nurse rig was used to bring the spray loads to the applicators. Worker 101 applying methomyl on 6/12 – 6/13/96 in arbor-trellised vineyards also mixed and loaded the pesticide all other workers, worked only as applicators. Except for applicators 103 and 105 applying methomyl in enclosed cabs on 6/11/96, all other applicators performed their work without use of enclosed cabs. Table 2 summarizes the type of equipment used for spraying and outer clothing worn by the workers. All workers wore work boots,

long pants, and the dosimetry shirt and socks under their outer clothing listed in Table 2. They did not wear a work shirt under the dosimetry shirt due to the 95-degree temperatures at the time of the applications. All spray equipment was tractor drawn. The overvine sprayer sprayed two rows at a time and the undervine and airblast sprayer treated one side of two different rows at the same time.

Table 1. Dates of worker exposure monitoring, number of workers monitored, pesticides used, acres treated and vineyard trellis system.

Date	Study ID	Workers	Pesticides monitored	Acres	Trellis type
6/11/1996	JS50	3	Methomyl <sup>a</sup>	40	T-type
6/12/1996	JS51	1	Methomyl	9	Arbor
6/13/1996	JS52	1	Methomyl	15	Arbor
5/2/1997	JS53	2	Iprodione <sup>b</sup>	90	Arbor
5/2/1997	JS53	2	Iprodione/Myclobutanil <sup>c</sup>	180	T-type
5/21/1997	JS56	4	Imidacloprid <sup>d</sup> /Myclobutanil	140	Arbor
5/30/1997	JS57	2	Imidacloprid/Myclobutanil	40	T-type
5/30/1997	JS57	2	Imidacloprid	60	T-type

a Methomyl was applied as Lannate, EPA# 352-342 AA, 90% active ingredient

b Iprodione was applied as Rovral 50, EPA# 264- 532-AA, 50% active ingredient

c Myclobutanil was applied as Rally 40W, EPA# 707-215 AA, 40% active ingredient.

d Imidacloprid was applied as Provado Solupak, EPA# 3125- 428-AA, 75% active ingredient

Table 2. Protective clothing worn by workers, trellis type and spray rig reported by study identification.

Study ID	Worker number	Trellis type	Sprayer Type <sup>a</sup>	Coverall or Rainsuit	Gloves	Eye Wear	Respirator	Enclosed Cab
JS50	103	T-type	Overvine	Tyvek	Yes	Yes	Yes	Yes
JS50	104	T-type	Overvine	Tyvek	Yes	Yes	Yes	No
JS50	105	T-type	Airblast	Cloth	Yes	Yes	Yes	Yes
JS51	101 <sup>b</sup>	Arbor	Undervine	Rainsuit	Yes	Yes	Yes	No
JS52	101 <sup>b</sup>	Arbor	Undervine	Rainsuit	Yes	Yes	Yes	No
JS53	101	Arbor	Airblast	Rainsuit	Yes	Yes	No	No
JS53	102	Arbor	Airblast	Rainsuit	Yes	Yes	No	No
JS53	103	T-type	Overvine	Rainsuit	Yes	Yes	No	No
JS53	104	T-type	Overvine	Rainsuit	Yes	Yes	No	No
JS56	101	Arbor	Airblast	Cloth <sup>c</sup>	Yes	Yes	No	No
JS56	102	Arbor	Airblast	Cloth <sup>c</sup>	Yes	Yes	No	No
JS56	103	Arbor	Airblast	Cloth <sup>c</sup>	Yes	Yes	No	No
JS56	104	Arbor	Airblast	Cloth <sup>c</sup>	Yes	Yes	No	No
JS57	101	T-type	Overvine	Long sleeve shirt & pants	Yes	Yes	No	No
JS57	102	T-type	Overvine		Yes	Yes	No	No
JS57	103	T-type	Overvine	Cloth	Yes	Yes	No	No
JS57	104	T-type	Overvine	Cloth	Yes	Yes	No	No

a. Overvine sprayer nozzles are mounted on a boom, the undervine sprayer nozzles are mounted on the frame of the sprayer, both sprayers operate at high pressures while the airblast sprayers uses fan assist.

b. Worker 101 also mixed, loaded and transferred the pesticide prior to application

c. Workers wore a rainsuit jacket over the cloth coveralls. The front of the rainsuit was not closed so only the workers back had the additional protection of the rainsuit.

### Inhalation monitoring

Inhalation monitoring was conducted over the duration of the exposure period. Samples were collected using personal air pumps operating at a flow of two liters per minute. The collection matrix was a 37-mm glass fiber filter, type AE, 1  $\mu\text{m}$  pore size (SKC number 225-7), backed with a support pad<sup>1</sup>. The filter was housed in a plastic cassette and sealed with self-sealing bands. It was attached via vinyl tubing to a personal air pump clipped to a webbed belt and the cassette was secured to the worker's collar region. Airflow was measured at the end of the sampling period and elapsed time was recorded from each pump and multiplied by the liters per minute of airflow for total liters collected. At the end of the sampling period the cassettes were removed and the ends capped, then put in a track seal bag. The bag with cassettes was placed in an insulated cooler on dry ice.

### Dermal exposure

Dermal exposure to the torso and arms was measured using 100% cotton long-sleeved T-shirts. The long-sleeved T-shirts were worn for the duration of the monitoring interval. White knee-length socks (80% cotton and 20% polyester) were used to measure residues for the lower leg and foot regions. Socks and shirts were worn next to worker's skin. Twelve-ply 100% cotton gauze patches enclosed in a foil-lined patch holder with an exposed surface area of 23.7  $\text{cm}^2$  were used to measure exposure to the thigh region. Patches were attached to the inside of the protective clothing coveralls or rain suits to the front and back of each thigh (4 total). Hand and face/neck exposure was measured separately by wiping each area with a series of two 100% cotton cloths, each approximately 6 x 8-inch in size and moistened with 0.05% solution of sodium sulfosuccinate in water. Wipes for each region were collected at the end of the workday. For the hands, additional sampling was conducted before any break, or at any time the worker wished to clean his hands. Wipes for each region were combined as one sample for each worker each day. Wipe samples were placed in one-pint canning jars capped with aluminum foil and sealed with standard canning lids and rings. Dermal sample collection at the end of the study day was conducted in the following order starting with hand wipes, face/neck wipes, long-sleeved T-shirt, removal of the socks and patches. The T-shirt and socks were placed in separate labeled track seal bags and then in a second bag. All dermal exposure samples were stored frozen on dry ice.

### Applications

Treatments started around 1900 hours. Each load took about 20 minutes to spray. An additional 20 minutes was required to drive and reload the spray tank.

### Sample analysis

Sample analysis for methomyl, myclobutanil, iprodione and imidacloprid was performed by the California Department of Food and Agriculture (CDFA) Center for Analytical Chemistry.

Ethyl acetate was used for the extraction of dermal and inhalation samples of myclobutanil, iprodione and imidacloprid. Extraction volumes for gauze patches, wipes, filters, socks and T-shirts in mL were, 50, 150, 15, 150 and 2000, respectively. Final volumes for gauze patches, wipes, filters, socks and T-shirts in mL were, 10, 15, 3, 75 and 400, respectively. Methanol was used for the extraction of dermal and inhalation samples of methomyl. Final volumes for gauze patches, wipes, filters, socks and T-shirts in mL were, 5, 200, 50, 50 and 200, respectively. Dermal samples are rotated for one hour. Filter samples stand in solvent for one hour with occasional shaking.

Analytical equipment conditions for myclobutanil, iprodione and imidacloprid:

Liquid chromatograph: Hewlett-Packard 1050 system

Column: 15 cm Absorbosphere C8 Alltech cartridge system

Flow rate: 1 mL/minute (min)

Temperature: ambient

Gradient: 10/90 to 90/10 (acetonitrile/water %) 15 min, hold 3 min, reset to 10/90, and stop at 22 min.

Injection: 19 µL

Detector: Hewlett Packard 1050 Variable Wavelength Detector at 233nm

Retention times: myclobutanil 13.5 min, iprodione 14.2 min, imidacloprid 8.2 min.

Analytical equipment conditions for methomyl:

Liquid Chromatograph: PerkinElmer Series 4 with ISS-100 Autosampler

Column: Alltech Hypersil C18, 150 mm x 4.6 mm, 5mm

Solvent Profile:

Sector	Minutes	Flow, mL/min	%H <sub>2</sub> O	Acetylnitrile
Equilibrium	4.0	1.0	90	10
1	1.0	1.0	90	10
2	6.0	1.0	20	80
3	4.0	1.0	20	80

Post Column: Pickering PCX 5000, Flow Rate: 0.3 mL/min, temperature of hydrolysis: 100°C

Detector: Shimadzu RF-535, excitation wavelength: 350 nm, emission wavelength: 450 nm

Retention time: 7.1 minutes

Table 3 reports the laboratory matrix fortifications and recoveries for the pesticides. Field fortifications were not performed because it was not known what pesticides were to be applied until the day of the monitoring. At least one matrix fortification was analyzed with every sample batch. The active ingredient was pipetted on to the matrices. Recoveries for the shirts and socks were greater than 87%. Recoveries for the wipes and patches averaged over 75%. The filter recoveries were lower averaging 73%. Table 4 reports the limit of quantification (LOQ) for each matrix by pesticide.

Table 3. Laboratory pesticide fortifications (µg) and recovery %.

Matrix	µg Methomyl	%	µg Imidacloprid	%	µg Myclobutanil	%	µg Iprodione	%
T-shirts	10 100	120 96	2000	94	2000	101	2000	99
Socks	3	108	750	88	750	87	750	91
Filters	3	96	20	69	20	65	20	61
Wipes	5 200	93 89	150	72	150	86	150	86
Patches	1	97	50	78	50	87	50	82

Table 4. Limits of quantification ( $\mu\text{g}$ ) for all matrices and pesticides monitored.

Matrix	Methomyl	Imidacloprid	Myclobutanil	Iprodione
T-shirts	11.0	20.0	70.0	30.0
Socks	2.7	7.5	16.0	7.5
Filters	2.0	0.5	1.0	0.5
Cotton wipes	6.0	1.5	4.5	1.5
Patches	0.5	1.0	2.0	1.0

#### Data analysis

Sample data were entered into a relational database<sup>(2)</sup>. Potential dermal exposures were calculated directly by summing the residues found on the skin wipes and clothing. Patch results were summed, divided by the surface area of the patches and multiplied by the surface area of the thighs ( $3663 \text{ cm}^2$ )<sup>(3)</sup>. Potential inhalation exposure was calculated by adjusting filter residues for pump flow, elapsed time and a 14 L/min breathing rate<sup>(3)</sup>. Where a sample result was below the LOQ, half this level was used in calculating exposure.

### Results and Discussion

Applicators' work experience ranged from less than one year up to 17 years. All applicators were male, between 21 and 46 years of age. Twelve different applicators were involved in the seventeen monitoring days.

Except for one worker applying methomyl, who was the only worker to also perform his own mixing and loading tasks, total potential dermal exposures were below 1 mg. Tables 5 through 8 present mean daily potential dermal exposure for all workers monitored by pesticide. Table 9 presents potential inhalation exposure to the pesticides, by worker. Raw data results are reported in the appendix. In general, it is expected the more material applied, the more potential for dermal exposure to the worker. However, there was no correlation in potential worker exposure either between or within the workers for pounds applied or hours exposed.

Table 5 shows the methomyl potential dermal exposures that ranged from 28 – 1,428  $\mu\text{g}$ . For the one worker with the highest exposure, 85% of the exposure was to the arms and torso (long-sleeve T-shirt). For the five workers monitored, half the face and neck wipe samples were below the LOQ. There was only one positive sample on a front thigh patch and two of the five sock samples were positive at levels of 4  $\mu\text{g}$  or below. The shirt results ranged from below the LOQ to 1,400  $\mu\text{g}$ . In treating the T-type trellised vineyards two of the applicators performed their work while in enclosed cabs. Also, the worker spraying the arbor-trellised vineyards also had to do his own mixing and loading while the three workers who treated the T-type trellised vineyards did not do their own mixing and loading. These two factors of enclosed cabs for two workers and the applicator treating the arbor trellised vineyards had to do his own mixing and loading confounds any comparison between the different trellis types and worker exposure.

Iprodione dermal exposure is presented in Table 6. Potential dermal exposure ranged from 133 – 230  $\mu\text{g}$ . Detectable levels of iprodione were found in all but three samples. The workers also applied more iprodione at 18 to 38 pounds for the workday compared to the range of pounds applied per day for the other three pesticides (0.4 - 10.8 lb/day). Potential dermal exposures calculated per pound of iprodione

applied ranged from 5 – 13 µg. Applicator exposure levels were low for spray treatments performed under either trellis system with all workers wearing rainsuits.

For imidacloprid no more than 1.2 pounds of material was applied per worker per day with estimated potential dermal exposures of less than 50 µg as shown in Table 7. Positive dermal exposure samples were found on the face/neck area and the hands. The shirt, socks and patch dosimeters were all below the LOQ for these matrices with half the LOQ substituted for these samples to calculate potential dermal exposure. If only the positive samples are taken into account the results showed a slight increase in dermal exposure for the workers treating arbor-trellised grapes.

Myclobutanil exposure results are presented in Table 8. Pounds of myclobutanil applied did not exceed 3.5 pounds per day and again over half the results were below the LOQ. No long-sleeved T-shirts or thigh patches had positive results. Three of the eight sock samples were negative with the positives ranging from 30 – 89 µg. Half the face/neck wipers were negative and the highest level detected in a wipe was 11 µg. Results for hand measurements ranged from less than the LOQ to – 25 µg. While a large percentage of the samples were below their respective LOQ's, when the results were normalized on a per hour basis the T-type trellis applications showed an increase in dermal exposure, averaging 85 µg to 23 µg for the workers spraying in arbor trellised vineyards. The reverse of this occurred for the inhalation results with the arbor trellised applicators averaging greater than 1 µg to the less than 0.5 µg for the T-type trellis applicators.

Potential inhalation exposures (PIE) in Table 9 ranged from 0.003 - 0.012 mg/hr. The highest level was in an arbor-trellised vineyard being treated with methomyl. Methomyl applications to T-trellised vineyards were below the LOQ (PIE <0.006 mg/hr). For iprodione, all results were positive and PIE ranged from 0.002 to 0.008 mg/hr. Myclobutanil PIE were less than 0.002 mg/hr and imidacloprid had only one positive result with an estimated PIE of 0.0003 mg/hr.

Ideally, the monitoring would occur in both types of vineyards at the same time. However, the practice of farming is not always predictable and monitoring both treatments under the same conditions was not always possible. Use of the methomyl data is limited because of the differences in treatments. The results from the treatments using the pesticides imidacloprid and iprodione do not suggest any difference in exposure potential between the workers treating the arbor or T-type trellised vineyards. Additionally, the results were so low that almost half the samples were below the detection limit with the microgram range of results fairly similar and the exposures trivial. Results from the myclobutanil applications seem to be slightly higher for the T-type trellis applications but these applications were made on different days and very little material was used. While the inhalation results for myclobutanil showed the reverse with the arbor trellis applicator showing the higher results. From this limited data it does not appear that spraying in arbor-trellised vineyards would pose an additional hazard to the applicators.



The study “ Monitoring of Ground Applicators Applying Pesticides in Arbor Trellised Vineyards or T-Type Cross Arm Trellised Vineyards”, Worker Health and Safety Project Number 9503 followed the protocol “Exposure of Pesticide Applicators in Trellised and Conventional Grape Operations”. The resulting data and study report were audited January 7 – 9, 2004. The audit was reported to the study director and branch management January 12, 2004.

*Original signed by K. Orr*

*March 10, 2004*

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Kathy Orr, Quality Assurance Officer  
Worker Health and Safety Branch

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Date

### **References:**

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3. Thongsinthusak T, Ross J, Meinders D. Guidance for the preparation of human pesticide exposure assessment documents. (HS-1612) Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, Sacramento, California (1993).

Table 5. Methomyl potential dermal exposure (PDE) to ground applicators spraying in vineyards with arbor and T-type trellised grapes, results in  $\mu\text{g}$ .

Date	Study ID	Worker	Growing method	Face/neck	Hands	Torso /arms	Lower legs/feet	Thigh	PDE	lbs applied	PDE/lb applied	Hours applied	PDE/hour
6/12/1996	JS51	101 <sup>a</sup>	arbor	49	193	112	4	35	393	5.4	73	2.1	187
6/13/1996	JS52	101 <sup>a</sup>	arbor	219	3 <sup>b</sup>	1193	3	10 <sup>c</sup>	1428	10.8	132	3.8	376
6/11/1996	JS50	103 <sup>d</sup>	T-type	3 <sup>b</sup>	22	13	1.4 <sup>b</sup>	10 <sup>c</sup>	49	9	5	2.4	21
6/11/1996	JS50	104	T-type	3 <sup>b</sup>	8	5.5 <sup>b</sup>	1.4 <sup>b</sup>	10 <sup>c</sup>	28	9	3	2.4	12
6/11/1996	JS50	105 <sup>d</sup>	T-type	3 <sup>b</sup>	3 <sup>b</sup>	14	1.4 <sup>b</sup>	10 <sup>c</sup>	31	7.2	4	2.4	13

a Worker 101 also mixed and loaded methomyl while workers 103, 104 and 105 only worked as applicators.

b Result below the limit of quantification (LOQ), half the LOQ was substituted.

c Result below the LOQ, half the LOQ was substituted - patch results were summed, divided by the surface area of the patches and multiplied by the surface area of the thighs (3663  $\text{cm}^2$ )

d Workers were in enclosed cabs during application.

Table 6. Iprodione potential dermal exposure (PDE) to ground applicators spraying in vineyards with arbor and T-type trellised grapes, results in  $\mu\text{g}$ .

Date	Study ID	Worker	Growing method	Face/neck	Hands	Torso /arms	Lower legs/feet	Thigh	PDE	lbs applied	PDE/lb applied	Hours applied	PDE/hour
5/2/1997	JS53	101	arbor	0.8 <sup>a</sup>	4	115	17	97	234	18	13	6	39
5/2/1997	JS53	102	arbor	0.8 <sup>a</sup>	2	52	37	39	131	18	7	6.1	21
5/2/1997	JS53	103	T-type	4.0	7	136	50	19 <sup>b</sup>	216	38.25	6	8.8	25
5/2/1997	JS53	104	T-type	2.0	5	51	48	85	191	38.25	5	9	21

a Result below the limit of quantification (LOQ), half the LOQ was substituted.

b Result below the LOQ, half the LOQ was substituted - patch results were summed, divided by the surface area of the patches and multiplied by the surface area of the thighs (3663  $\text{cm}^2$ )

Table 7. Imidacloprid potential dermal exposure (PDE) to ground applicators spraying in vineyards with arbor and T-type trellised grapes, results in µg.

Date	Study ID	Worker	Growing method	Face/neck	Hands	Torso /arms	Lower legs/feet	Thigh	PDE	lbs applied	PDE/lb applied	Hours applied	PDE/ hour
5/21/1997	JS56	101	arbor	1.5	0.8 <sup>a</sup>	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	36	1.2	30	5.7	6
5/21/1997	JS56	102	arbor	4	5.0	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	42	1.2	35	5.7	7
5/21/1997	JS56	103	arbor	4	12.0	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	49	1.2	41	5.5	9
5/21/1997	JS56	104	arbor	4	4.0	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	41	1.2	34	5.5	7
5/30/1997	JS57	101	T-type	0.8 <sup>a</sup>	3.0	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	37	0.4	93	3.3	11
5/30/1997	JS57	102	T-type	0.8 <sup>a</sup>	3.0	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	37	0.4	93	3.3	11
5/30/1997	JS57	103	T-type	0.8 <sup>a</sup>	0.8 <sup>a</sup>	10 <sup>a</sup>	3.75 <sup>a</sup>	19 <sup>b</sup>	35	1.17	30	5.3	7
5/30/1997	JS57	104	T-type	0.8 <sup>a</sup>	3.0	10 <sup>a</sup>	NS <sup>c</sup>	NS <sup>c</sup>	37 <sup>d</sup>	1.17	32	5.3	7

a Results below the limit of quantification (LOQ), half the LOQ was substituted.

b Result below the LOQ, half the LOQ was substituted - patch results were summed, divided by the surface area of the patches and multiplied by the surface area of the thighs (3663 cm<sup>2</sup>)

c NS no sample, half the LOQ was substituted because all other worker results were below the LOQ.

d PDE uses half the LOQ for the lower legs, feet and thigh area to obtain result.

Table 8. Myclobutanil potential dermal exposure (PDE) to ground applicators spraying in vineyards with arbor and T-type trellised grapes, results in µg.

Date	Study ID	Worker	Growing method	Face/neck	Hands	Torso /arms	Lower legs/feet	Thigh	PDE	lbs applied	PDE/lb applied	Hours applied	PDE/ hour
5/2/97	JS53	103	T-type	1.3 <sup>a</sup>	10.0	35 <sup>a</sup>	89	39 <sup>b</sup>	174	2.1	83	2	87
5/2/97	JS53	104	T-type	1.3 <sup>a</sup>	1.3 <sup>a</sup>	35 <sup>a</sup>	29	39 <sup>b</sup>	106	2.1	50	2	53
5/21/97	JS56	101	arbor	1.3 <sup>a</sup>	1.3 <sup>a</sup>	35 <sup>a</sup>	34	39 <sup>b</sup>	111	3.5	32	5.7	19
5/21/97	JS56	102	arbor	10.0	17.0	35 <sup>a</sup>	30	39 <sup>b</sup>	131	3.5	37	5.7	23
5/21/97	JS56	103	arbor	1.3 <sup>a</sup>	25.0	35 <sup>a</sup>	8 <sup>a</sup>	39 <sup>b</sup>	108	3.5	31	5.5	20
5/21/97	JS56	104	arbor	11.0	12.0	35 <sup>a</sup>	71	39 <sup>b</sup>	168	3.5	48	5.5	30
5/30/97	JS57	101	T-type	3.0	12.0	35 <sup>a</sup>	8 <sup>a</sup>	39 <sup>b</sup>	97	0.4	243	1	97
5/30/97	JS57	102	T-type	3.0	19.0	35 <sup>a</sup>	8 <sup>a</sup>	39 <sup>b</sup>	104	0.4	260	1	104

a Result below the limit of quantification (LOQ), half the LOQ was substituted.

b Result below the LOQ, half the LOQ was substituted - patch results were summed, divided by the surface area of the patches and multiplied by the surface area of the thighs (3663 cm<sup>2</sup>)

Table 9. Potential inhalation exposure<sup>a</sup> for all treatments reported in µg per hour at a 14 L per minute breathing rate

Date	Study ID	Worker	Trellis type	Methomyl	Iprodione	Myclobutanil	Imidacloprid
6/11/96	JS50	103	T-type	<6	-	-	-
6/11/96	JS50	104	T-type	<6	-	-	-
6/11/96	JS50	105	T-type	<6	-	-	-
6/12/96	JS51	101	arbor	12	-	-	-
6/13/96	JS52	101	arbor	7	-	-	-
5/2/1997	JS53	101	arbor	-	7.85	-	-
5/2/1997	JS53	102	arbor	-	1.97	-	-
5/2/1997	JS53	103	T-type	-	6.18	0.60	-
5/2/1997	JS53	104	T-type	-	3.79	0.44	-
5/21/1997	JS56	101	arbor	-	-	1.16	0.30
5/21/1997	JS56	102	arbor	-	-	0.89	<0.27
5/21/1997	JS56	103	arbor	-	-	1.43	<0.27
5/21/1997	JS56	104	arbor	-	-	1.47	<0.27
5/30/1997	JS57	101	T-type	-	-	<0.5	<0.27
5/30/1997	JS57	102	T-type	-	-	<0.5	<0.27
5/30/1997	JS57	103	T-type	-	-	-	<0.27
5/30/1997	JS57	104	T-type	-	-	-	<0.27

a Potential inhalation exposure was calculated by adjusting filter residues for pump flow, elapsed time and a 14 L/min breathing rate.

< Results were below the limit of quantification (LOQ), half the LOQ was substituted for the calculation.

- Indicates the pesticide was not used in the application.

Appendix 1: Raw data used to estimate potential dermal and inhalation exposure.  
Methomyl results in µg.

Study ID	Sample number	Lab number	Worker ID	Sample type	Result
JS50	1003	1429	103	Gauze patch	<0.5
JS50	1004	1430	104	Gauze patch	<0.5
JS50	1005	1431	105	Gauze patch	<0.5
JS50	1011	1433	103	Wipe	<6.0
JS50	1012	1434	104	Wipe	<6.0
JS50	1013	1435	105	Wipe	<6.0
JS50	1019	1437	103	Gauze patch	<0.5
JS50	1020	1438	104	Gauze patch	<0.5
JS50	1021	1439	105	Gauze patch	<0.5
JS50	1027	1440	103	Filter	<2.0
JS50	1028	1441	104	Filter	<2.0
JS50	1029	1442	105	Filter	<2.0
JS50	1035	1444	103	Wipe	22.3
JS50	1036	1445	104	Wipe	7.95
JS50	1037	1446	105	Wipe	<6.0
JS50	1042	1447	103	Socks	<2.7
JS50	1043	1448	104	Socks	<2.7
JS50	1044	1449	105	Socks	<2.7
JS50	1054	1452	103	T-shirt	13.1
JS50	1055	1453	104	T-shirt	<11.0
JS50	1056	1454	105	T-shirt	14.2
JS51	1001	1456	101	Gauze patch	<0.5
JS51	1009	1458	101	Wipe	48.7
JS51	1017	1460	101	Gauze patch	<0.5
JS51	1025	1461	101	Filter	3.47
JS51	1033	1463	101	Wipe	193
JS51	1040	1464	101	Socks	4.14
JS51	1052	1467	101	T-shirt	112
JS52	1001	1469	101	Gauze patch	0.897
JS52	1009	1471	101	Wipe	219
JS52	1017	1473	101	Gauze patch	2.38
JS52	1025	1474	101	Filter	3.59
JS52	1033	1476	101	Wipe	<6.0
JS52	1040	1477	101	Socks	3.46
JS52	1052	1480	101	T-shirt	1193

Appendix 1, continued: Raw data used to estimate potential dermal and inhalation exposure.  
Myclobutanil and iprodione results in µg,

Study ID	Sample number	Lab number	Worker ID	Sample Type	Myclobutanil	Iprodione
JS53	1001	1410	101	Gauze patch		<1.0
JS53	1002	1411	102	Gauze patch		<1.0
JS53	1008	1412	101	Wipe		<1.5
JS53	1009	1413	102	Wipe		<1.5
JS53	1015	1414	101	Gauze patch		2.51
JS53	1016	1415	102	Gauze patch		1.00
JS53	1022	1416	101	Filter		6.77
JS53	1023	1417	102	Filter		1.70
JS53	1029	1418	101	Wipe		3.52
JS53	1030	1419	102	Wipe		1.71
JS53	1036	1420	101	Socks		16.70
JS53	1037	1421	102	Socks		37.40
JS53	1052	1425	101	T-shirt	<70.0	115.00
JS53	1053	1426	102	T-shirt	<70.0	51.90
JS53	1003	1427	103	Gauze patch	<2.0	<1.0
JS53	1004	1428	104	Gauze patch	<2.0	<1.0
JS53	1005	1429	105	Gauze patch	<2.0	2.34
JS53	1010	1430	103	Wipe	<4.5	3.57
JS53	1011	1431	104	Wipe	<4.5	1.81
JS53	1012	1432	105	Wipe	<4.5	<1.5
JS53	1017	1433	103	Gauze patch	<2.0	<1.0
JS53	1018	1434	104	Gauze patch	<2.0	2.23
JS53	1024	1435	103	Filter	0.75	7.76
JS53	1025	1436	104	Filter	0.57	4.89
JS53	1026	1437	105	Filter	<1.0	<0.5
JS53	1031	1438	103	Wipe	10.40	6.69
JS53	1032	1439	104	Wipe	<4.5	5.45
JS53	1038	1440	103	Socks	89.1	50.10
JS53	1039	1441	104	Socks	29.2	47.60
JS53	1040	1442	105	Socks	<2.7	24.60
JS53	1054	1446	103	T-shirt	<70.0	136.00
JS53	1055	1447	104	T-shirt	<70.0	51.00
JS53	1056	1448	105	T-shirt	<70.0	43.80

a. Blank cells mean those workers did not apply the pesticide on that day.

Appendix 1, continued: Raw data used to estimate potential dermal and inhalation exposure  
Myclobutanil and imidacloprid results in µg.

Study ID	Sample number	Lab number	Worker ID	Sample Type	Myclobutanil	Imidacloprid
JS56	1001	1822	101	Gauze patch	<2.0	<1.0
JS56	1002	1823	102	Gauze patch	<2.0	<1.0
JS56	1003	1824	103	Gauze patch	<2.0	<1.0
JS56	1004	1825	104	Gauze patch	<2.0	<1.0
JS56	1005	1826	105	Gauze patch	<2.0	<1.0
JS56	1008	1827	101	Wipe	<4.5	1.52
JS56	1009	1828	102	Wipe	9.96	3.98
JS56	1010	1829	103	Wipe	<4.5	4.27
JS56	1011	1830	104	Wipe	10.80	4.28
JS56	1012	1831	105	Wipe	<4.5	<1.5
JS56	1015	1832	101	Gauze patch	<2.0	<1.0
JS56	1016	1833	102	Gauze patch	<2.0	<1.0
JS56	1017	1834	103	Gauze patch	<2.0	<1.0
JS56	1018	1835	104	Gauze patch	<2.0	<1.0
JS56	1022	1836	101	Filter	1.15	0.30
JS56	1023	1837	102	Filter	0.89	<0.5
JS56	1024	1838	103	Filter	1.40	<0.5
JS56	1025	1839	104	Filter	1.44	<0.5
JS56	1026	1840	105	Filter	<1.0	<0.5
JS56	1029	1841	101	Wipe	<4.5	<1.5
JS56	1030	1842	102	Wipe	16.70	5.49
JS56	1031	1843	103	Wipe	24.50	12.10
JS56	1032	1844	104	Wipe	12.40	3.70
JS56	1036	1845	101	Socks	33.90	<7.5
JS56	1037	1846	102	Socks	30.10	<7.5
JS56	1038	1847	103	Socks	NQ	<7.5
JS56	1039	1848	104	Socks	71.30	<7.5
JS56	1040	1849	105	Socks	NQ	<7.5
JS56	1052	1853	101	T-shirt	<70.0	<30.0
JS56	1053	1854	102	T-shirt	<70.0	<30.0
JS56	1054	1855	103	T-shirt	<70.0	<30.0
JS56	1055	1856	104	T-shirt	<70.0	<30.0
JS56	1056	1857	105	T-shirt	<70.0	<30.0

NQ not quantified too much interference

Appendix 1, continued: Raw data used to estimate potential dermal and inhalation exposure.  
Myclobutanil and imidacloprid results in µg.

Study ID	Sample number	Lab number	Worker ID	Sample Type	Myclobutanil <sup>a</sup>	Imidacloprid
JS57	1001	2188	101	Gauze patch	<2.0	<1.0
JS57	1002	2189	102	Gauze patch	<2.0	<1.0
JS57	1003	2207	103	Gauze patch	<2.0	<1.0
JS57	1005	2190	105	Gauze patch	<2.0	<1.0
JS57	1008	2191	101	Wipe	4.73	<1.5
JS57	1009	2192	102	Wipe	3.68	<1.5
JS57	1010	2208	103	Wipe		<1.5
JS57	1011	2209	104	Wipe		<1.5
JS57	1015	2205	101	Gauze patch	<2.0	<1.0
JS57	1016	2206	102	Gauze patch	<2.0	<1.0
JS57	1017	2214	103	Gauze patch	<2.0	<1.0
JS57	1022	2194	101	Filter	<1.0	<0.5
JS57	1023	2195	102	Filter	<1.0	<0.5
JS57	1024	2210	103	Filter	<1.0	<0.5
JS57	1025	2211	104	Filter	<1.0	<0.5
JS57	1026	2196	105	Filter	<1.0	<0.5
JS57	1029	2197	101	Wipe	12.20	3.16
JS57	1030	2198	102	Wipe	19.10	3.10
JS57	1031	2212	103	Wipe		<1.5
JS57	1032	2213	104	Wipe		2.60
JS57	1036	2199	101	Socks	<2.7	<7.5
JS57	1037	2200	102	Socks	<2.7	<7.5
JS57	1038	2215	103	Socks		<7.5
JS57	1039	2216	104	Socks		<7.5
JS57	1040	2201	105	Socks	<2.7	<7.5
JS57	1052	2202	101	T-shirt	<70.0	<30.0
JS57	1053	2203	102	T-shirt	<70.0	<30.0
JS57	1054	2217	103	T-shirt		<30.0
JS57	1055	2218	104	T-shirt		<30.0
JS57	1056	2204	105	T-shirt	<70.0	<30.0

a. Blank cells mean those workers did not apply the pesticide on that day.